DIVISION 500 - STRUCTURES

SECTION 501 - FOUNDATION PILES

501.01 Description This work shall consist of furnishing and driving piles and casings, of the types and dimensions specified on the contract plans, to the required ultimate capacity. Piles shall conform to and be installed, as detailed in these specifications, in reasonably close conformity to the lines, grades, and locations shown on the plans or as authorized by the Resident. Work under this item shall also consist of any pile testing specified by the project contract plans and described in these specifications.

501.02 Materials Materials shall meet the requirements of the following sections of Division 700 - Materials:

Steel Pipe Piles	711.01
H-Beam Pile Tips	711.10
Structural Steel	713.01

H-beam piles shall be structural steel and shall meet the requirements of AASHTO M183/ 183M (ASTM A36/A36M). Mill test reports will be required. Notch toughness tests will not be required.

Concrete for Steel Pipe Piles and Steel Casings shall be Class S and shall meet the requirements of Section 502 - Structural Concrete.

Steel casings shall conform to the material requirements of Section 711.01 - Steel Pipe Piles.

Reinforcing steel for Steel Pipe Piles and Steel Casings when called for, shall meet the requirements of Section 503 - Reinforcing Steel.

501.021 Ordering Piles The Contractor shall order all pilings from an itemized list of order lengths provided by the Resident. When extensions of piles are necessary, the extension lengths will be ordered by the Contractor from a written list provided by the Resident.

501.03 Equipment for Driving Piles

Hammers Piles shall be driven with approved power-actuated impact hammers powered with steam/air, diesel fuel or hydraulics (hereinafter referred to as power hammers). Gravity drop hammers (hereinafter referred to as drop hammers), except as noted on the plans, shall only be used to drive timber piles. When drop hammers are used to drive timber piles, the ram shall be between 900 and 1600 kg [2,000 and 3,500 lb] and the height of drop shall not exceed 5 m [15 ft]. In no case shall the ram weight be less than the combined weight of the drive head and pile. All drop hammers shall be equipped with hammer guides to insure concentric impact on the drive head.

With the written approval of the Resident, installation of non-displacement piles may be initiated with the use of a power-actuated vibratory hammer powered with electricity or hydraulics (hereinafter referred to as vibratory hammers). Vibratory hammers shall not be used for precast concrete piles due to pile damage and bending stress considerations. Vibratory hammers shall not be used to set piles which develop bearing capacity primarily from friction with the surrounding soils through the pile length. All piles initially driven using a vibratory hammer shall be driven to the required capacity in accordance with the approved refusal criteria using a power hammer.

The plant and equipment furnished for steam and air power hammers shall have sufficient capacity to maintain, at the hammer under working conditions, the volume and pressure specified by the manufacturer. The plant and equipment shall be equipped with accurate pressure gauges that are easily accessible to the Resident. The weight of the striking parts of air and steam power hammers shall not be less than 1/3 the weight of drive head and pile being driven.

Open-end (single acting) diesel power hammers shall be equipped with a device such as rings on the ram or a scale (jump stick) extending above the ram cylinder, to permit the Resident to visually determine hammer stroke at all times during pile driving operations. In addition, the Contractor shall provide the Resident with a chart from the hammer manufacturer equating stroke and blows per minute to energy imparted for the open-end diesel hammer to be used. Closed-end (double acting) diesel power hammers shall be equipped with a bounce chamber pressure gauge, in good working order, mounted near ground level to be easily read by the Resident. Also, the Contractor shall provide the Resident with a chart, calibrated within 90 days of use, of actual hammer performance, equating bounce chamber pressure to either equivalent energy or stroke for the closed-end diesel hammer to be used.

Double-acting hydraulic power hammers shall be equipped with digital readouts, easily accessible to the Resident,

showing pertinent system criteria, including but not limited to energy imparted to the pile, to enable the Resident to visually determine whether or not the refusal criteria has been met. The Contractor shall provide these refusal criteria to the Resident for approval. Refusal criteria shall be generated using the Wave Equation, if specified, and dynamic test results. In addition, the Contractor shall provide the Resident with a chart, calibrated within 90 days of use, of actual hammer performance.

Approval of Pile Driving Equipment All pile driving equipment furnished by the Contractor shall be approved by the Resident prior to use. All pile driving equipment shall be sized such that the specified piles can be driven to the required ultimate capacity, without damage, as indicated on the plans. Approval of the pile driving equipment by the Resident will be based on the wave equation analysis unless The Alternate Approval Method, as described herein, is designated on the plans.

The Contractor shall submit to the Resident the necessary pile driving equipment information at least 14 days prior to driving piles. The Resident will respond in writing as to the adequacy of the Contractor's driving equipment proposal.

The Contractor will be notified of the acceptance or rejection of the driving system within 7 calendar days of the Resident's receipt of the Pile and Driving Equipment Data Form, available in Design and Construction of Driven Pile Foundations, FHWA-HI-97-013, Dec. 1996, page 12-11**.**

If the wave equation analyses show that the driving system is unacceptable, the Contractor shall modify or replace the proposed equipment, at its expense, until subsequent wave equation analyses indicate the piles can be driven to the desired ultimate capacity, without damage. The Resident will notify the Contractor of the acceptance or rejection of the revised driving system within 7 calendar days of receipt of a revised Pile and Driving Equipment Data Form.

The criteria that the Resident will use to evaluate the driving equipment from the wave equation results consists of both the required number of hammer blows per 25 mm [blows per in] at the required ultimate pile capacity and the pile stresses during driving. The required number of hammer blows indicated by the wave equation at the ultimate pile resistance shall be between 3 and 15 blows per 25 mm [3 and 15 blows per in] for the driving equipment to be acceptable. The wave equation analysis shall include a stopping criterion, where the number of blows per 25 mm [blows per in], for a number of 25 mm [1 in] intervals, is clearly defined. Stopping criteria shall be approved by the Resident.

In addition, for the driving equipment to be acceptable, the pile stresses indicated by the wave equation shall not exceed

the values where pile damage is impending. The point of impending damage in steel piles is defined as a compressive driving stress of 90% of the specified yield stress of the pile material. For timber piles, the compressive driving stress shall not exceed three times the allowable working stress shown on the plans.

The Alternate Approval Method of driving will be used when specified on the plans. The Alternate Approval Method requires that the energy of the driving equipment submitted for approval on the Pile and Driving Equipment Data Form, be rated by the manufacturer at or above the appropriate minimum energy level in Table 1 corresponding to the ultimate pile capacity shown on the plans.

TABLE 1 ALTERNATE APPROVAL METHOD
Minimum Pile Hammer Requirements

Ultimate Pile Capacity (kN)	(Kips)	Minimum Manufacturer's Rated Hammer Energy (kNm)	(Foot-pounds)
800 and under	(180 and under)	12.2	(9,000)
801 to 1334	(181 to 300)	20.3	(15,000)
1335 to 1868	(301 to 420)	27.1	(20,000)
1869 to 2400	(421 to 540)	32.5	(24,000)
2401 to 2669	(541 to 600)	35.3	(26,000)
2670 and over	(600 and over)		Wave Equation Required

During pile driving operations, the Contractor shall use the approved system. No variations in the driving system will be permitted without the Resident's written approval. Any change in the driving system will be considered only after the Contractor has submitted a revised equipment data form. The Contractor will be notified of the acceptance or rejection of the driving system changes within 7 calendar days of the Resident's receipt of the requested change. The time required for submission, review, and approval of a revised driving system shall not constitute the basis for a contract time extension to the Contractor.

Acceptance of the pile driving equipment does not relieve the Contractor of the responsibility to properly install the piling. The hammer acceptance and driving criteria will be based on commonly accepted hammer efficiencies, component properties, and soil parameters. Local soil conditions and the actual driving system will affect the driving. If

in the opinion of the Resident, the accepted driving system fails to perform satisfactorily during actual driving, the Department reserves the right to revise the driving criteria.

Drive System Components and Accessories

Leads Pile driver leads shall be constructed in such a manner as to afford freedom of movement of the hammer and to insure proper support of the pile during driving.

Followers Followers shall only be used when approved in writing by the Resident, or when specifically stated in the contract documents. In cases where a follower is permitted, the first pile in each group and every tenth pile driven thereafter shall be driven full length without a follower, to verify that adequate pile length is being attained to develop the desired pile capacity. The follower and pile shall be held and maintained in equal and proper alignment during driving. The follower shall be of such material and dimensions to permit the piles to be driven to the length determined necessary from the driving of the full-length piles. The final position and alignment of the first two piles installed with followers in each substructure unit shall be verified in accordance with location tolerances.

Hammer Cushion All power pile driving equipment shall be equipped with a suitable thickness of hammer cushion material to prevent damage to the hammer and pile and to insure uniform driving behavior. Hammer cushions shall be made of durable, manufactured materials, provided in accordance with the hammer manufacturer's guidelines except that all wood, wire rope, and asbestos hammer cushions are specifically disallowed and shall not be used. A striker plate as recommended by the hammer manufacturer shall be placed on the hammer cushion to insure uniform compression of the cushion material. The hammer cushion shall be inspected in the presence of the Resident when beginning pile driving at each pile group or after each 100 hours of pile driving, whichever is less. Any reduction of hammer cushion thickness exceeding 25% of the original thickness shall be replaced by the Contractor before driving is permitted to continue.

Helmet Piles driven with power hammers require an adequate drive head to distribute the hammer blow to the pile head. The helmet shall be axially aligned with the hammer and the pile. The helmet shall be guided by the leads and not be free-swinging. The helmet shall fit around the pile head in such a manner as to prevent transfer of torsional forces during driving while maintaining proper alignment of hammer and pile.

For special types of piles, appropriate driving heads, mandrels, or other devices shall be pro-vided in accordance with

the manufacturer's recommendations so that the piles may be driven without damage.

501.04 Driving Procedures and Tolerances The sequence of driving piles in any unit shall be subject to the approval of the Resident. The ground surface shall be brought to the bottom of the footing elevation before driving the piles. The Contractor shall furnish all assistance required to make any observations and measurements. The order of placing individual piles in pile groups shall be either starting from the center of the group and proceeding outwards in both directions or starting at the outside row and proceeding progressively across the group.

When driving is interrupted before final penetration is reached, data for the bearing capacity of the pile shall not be taken until at least 300 mm [12 in] of pile penetration is attained after driving has been resumed, or pile refusal has been attained.

The heads of all piles shall be plane and perpendicular to the longitudinal axis of the pile before the helmet is attached. Approval of the hammer relative to driving stress damage shall not relive the Contractor of responsibility for piles damaged because of misalignment of the leads, failure of cushion materials, failure of splices, malfunction of the pile hammer, or improper construction methods. Piles damaged for such reasons shall be rejected and replaced at the Contractors expense when the Resident determines that the damage impairs the strength of the pile.

The compressive stresses in steel piles during driving shall not exceed 90% if the yield stress, determined by Wave equation Analysis or Dynamic Pile Analyzer.

Jetting Jetting shall be done only with the permission of the Resident and must be addressed in the Contractor's SEWPCP. When water jets are used, the number of jets and the volume and pressure of the water at the nozzles shall be sufficient to erode freely the material adjacent to the piles. The plant shall have sufficient capacity to deliver at all times at least 690 kPa [100 psi] pressure at two 19 mm [¾ in] jet nozzles. Before the desired penetration is reached, the jets shall be withdrawn and the piles shall be driven with the hammer to the required penetration or bearing capacity.

Vibratory Hammers When permitted, piles initially driven using a vibratory hammer shall be driven to the required capacity in accordance with the approved refusal criteria using a power hammer. When permitted, such equipment shall be used to installing production piles only after the pile tip elevation of the ultimate pile capacity is established by load testing and/or piles driven with an impact hammer. Vibratory hammers may be used to initially set a pile to a maximum distance of 6.1 m [20 ft] from the expected tip elevation, at which point a power hammer shall be employed. If the pile

penetration rate is 300 mm [12 in] or less per minute, the use of a vibratory hammer should be discontinued and a power hammer employed. When a battered pile is initially set using a vibratory hammer, the hammer shall be mounted in a set of leaders. The ultimate capacity of piles driven with vibratory hammers shall be based on the driving resistance recorded during impact driving after the vibratory equipment has been removed. Vibrated piles not attaining the ultimate pile capacity at the ordered length shall be spliced, as required, at the Contractors cost, and driven with an impact hammer until the ultimate pile capacity is achieved as indicated by the appropriate criteria in Section 501.07. When the ultimate pile capacity is attained, the remaining piles shall be installed to similar depth with similar vibratory hammer power consumption and rate of penetration as the first pile.

Preaugering When necessary to obtain the specified pile penetration and when authorized by the Resident, the Contractor shall furnish the necessary drilling apparatus and drill holes, not greater that the least dimension of the pile top, to the proper depth and drive the piles therein. When specified in the contract documents, the Contractor shall prebore holes at pile locations and to the depths shown on the plans. Preaugered holes shall be of a size smaller than the diameter of diagonal of the pile cross section. If subsurface obstructions, such as boulders or rock layers are encountered, the hole diameter may be increase to the least dimension needed for pile installation. Any void space remaining around any type pile after driving shall be completely filled with sand or other approved material. The used of spuds, which are driven and removed to make a hole for inserting a pile, shall not be permitted in lieu of preboring.

Concrete shall not be placed in pipe piles until pile driving has progressed beyond a radius of 5 m [15 ft] from the pile to be concreted. If pile heave is detected for pipe piles that have been filled with concrete, the piles shall be redriven to the original position after the concrete has attained sufficient strength and a proper hammer-pile cushion system, is in place as is satisfactory to the Resident.

Heaved Piles Piles that have heaved more than 5 mm [¼ in] during the driving of other piles in a group shall be reseated to the required penetration or bearing capacity at the Contractor's expense.

Location and Alignment Tolerance The Contractor will be responsible to hold the piles in place to allowable tolerances. Piles shall be driven with a variation of not more than 20 mm/m [¼ in/ft] from the vertical or from the batter shown on the plans. For piles that cannot be inspected for axial alignment internally after installation, an alignment check shall be made before installing the last 1.5 m [5 ft] of pile, or after installation is completed provided the exposed portion of the piles is not less than 1.5 m [5 ft] in length. The Resident may require that driving be stopped in order to check the pile alignment. Pulling laterally on piles to correct misalignment, or splicing a properly aligned section of a misaligned

section shall not be permitted.

The cutoff elevation of piles for trestle bents shall not be out of position by more than 50 mm [2 in] from the dimensions shown on the plans. The cutoff elevation of piles, other than for trestle bents, shall not be out of position by more than 150 mm [6 in]. Actual embedment of the piles in the concrete shall be within 150 mm [6 in] of that shown on the plans. The as-driven centroid of load of any group at cutoff elevation shall be within 5% of the plan location of the designated centroid of load. No pile shall be nearer than 100 mm [4 in] from any edge of the cap. Any increase in size of the pile cap to meet this edge distance requirement shall be at the Contractor's expense.

501.05 Special Requirements for Steel Pipe Piles and Steel Casings Pipe piles shall be driven closed ended, unless otherwise specified. When open-ended pipe piles are specified or when the ends are not completely closed ended when driven, the inside of the pile shall be thoroughly cleaned out, and the inside walls cleaned by jetting or other means approved by the Resident. The sediment control form the cleaning operation shall be covered in the Contractor's SEWPCP.

Pipe piles shall be inspected and approved by the Resident immediately before concrete is placed. They shall be free from rupture and undue deformation and shall be free from water unless the Resident determines that the concrete can be placed without damage to the pile and such that the discharged water will be contained. The Contractor shall provide lights and other equipment necessary to inspect each pipe pile.

Portland cement concrete for filling the pipe piles shall be placed in one continuous operation to fill the pile completely without causing water contamination. An internal type vibrator shall be used in the top 8 m [25 ft]. Pile heads shall be protected and cured in accordance with Section 502 - Structural Concrete.

The placing of concrete and the driving of piles shall be scheduled so that fresh and setting concrete will not be injured by the pile driving.

Steel casings shall be driven over H-beam piles through steel templates located inside the casings. A reinforcing steel cage, when specified, shall be placed inside the casings with a minimum of 50 mm [2 in] coverage and the casings shall be filled with concrete to the elevation shown on the plans.

Full-length steel casings shall be used wherever practicable; however, splicing may be permitted when approved by the

Resident. The method of splicing shall be as follows:

a. Steel casings shall be spliced by full penetration butt joint welds.

b. When the casings are to be spliced while in a vertical position the welds shall be single-bevel groove welds with the use of back-up rings. When the casings are to be spliced while in a horizontal position, the welds shall be single-vee groove welds with the use of back-up rings.

c. Welded joints shall conform to the Standard Details. Welding, including welder qualifications, shall comply with the requirements of AWS D1.1, Structural Welding Code - Steel.

501.06 Defective Piles and Corrective Measures The procedure incident to the driving of piles shall not subject the piles to excessive and undue abuse causing deformation. Any pile damaged due to internal defects, improper driving, or driven below cutoff elevation, shall be considered defective and shall be corrected by and at the expense of the Contractor, by a method approved by the Resident.

501.07 Driven Pile Capacity, Pile Testing, and Acceptance Pile testing will be required as shown on the plans. Pile testing will be required to confirm that piles attain the required ultimate bearing capacity.

A static load test consists of the application of a known load to the pile or group of piles and the accurate measurement of the resulting displacement.

In the case of Steel Pipe Piles, no load shall be placed on the pile for at least 7 days after the concrete has been placed in the shell.

Static loading testing shall be conducted under the direction of the Resident, but the Contractor shall furnish all labor and equipment.

A dynamic load test consists of mounting instruments on the pile and accurately recording the output during driving using Pile Dynamic Analysis (PDA) equipment.

On completion of either static or dynamic load testing, any test or anchor piling, not a part of the finished structure,

shall be removed or cut off at least 300 mm [1 ft] below either the bottom of the footing or the finished ground elevation, whichever is lower.

Driven Pile Capacity - Wave Equation The piles shall be driven to the ultimate capacity as shown by the wave equation blows per 25 mm [blows/in] and the defined stopping criteria. The pile acceptance will be based on the ultimate pile capacity as determined by the wave equation analysis and the results of any dynamic or static pile tests, unless otherwise designated on the plans. When the Alternate Approval Method is specified on the plans, piles shall be driven to practical refusal of 10 blows per 25 mm [10 blows/in], or as approved by the Resident. Adequate pile penetration shall be considered to be obtained when the specified wave equation resistance criteria is achieved within 1.5 m [5 ft] of the pile toe elevation, based on ordered length. Piles not achieving the specified ultimate resistance within these limits shall be driven to penetration established by the Resident.

The wave equation resistance criteria will not be considered valid under any of the following conditions:

a. The hammer or striking part does not have a free fall.
b. The head of the pile becomes broomed or crushed.
c. The penetration is not reasonably quick and uniform.
d. There is an appreciable bounce after a blow.
e. The hammer is operated outside the parameters recommended by the manufacturer.

Static Load Test When a static load test is specified in the contract documents, load tests shall be performed by procedures set forth in ASTM D1143 using the quick load test method except that the test shall be taken to plunging failure or the capacity of the loading system. Testing equipment and measuring systems shall conform to ASTM D1143, except that the loading system shall be capable of applying 150% of the ultimate pile capacity or 9000 kN [2023 kips], whichever is less, and that a load cell and a spherical bearing plate shall be used. The Contractor shall submit to the Resident for approval, detailed plans, prepared by a licensed Professional Engineer, of the proposed loading apparatus. The apparatus shall be constructed to allow the various increments of the load to be placed gradually without causing vibration to the test pile. When the approved method requires the use of tension (anchor) piles, such tension piles shall be of the same type and diameter as the production piles and shall be driven in the location of permanent piles when feasible, except that timber or tapered piles installed in permanent locations shall not be used as tension piles.

The design load shall be defined as 50% of the failure load. The failure load of a pile tested under axial compressive

load is that load which produces a settlement at failure of the pile head equal to:

METRIC UNITS

For piles less than or equal to 610 mm in diameter or width:

$S_f = S + (4.0 + 0.008D)$

Where:

S_f = Settlement at failure in millimeters

D = Pile diameter or width in millimeters

S = Elastic deformation of total unsupported pile length in millimeters.

For piles greater than 610 mm in diameter or width:

$S_f = S + D/30$

US CUSTOMARY UNITS

For piles less than or equal to 24 inches in diameter or width:

$S_f = S + (0.16 + 0.008D)$

Where:

S_f = Settlement at failure in inches

D = Pile diameter or width in inches

S = Elastic deformation of total unsupported pile length in inches.

For piles greater than 24 inches in diameter or width:

$S_f = S + D/30$

The top elevation of the test pile shall be determined immediately after driving and again just before load testing to check for heave. Any pile that heaves more than 5 mm [¼ in] shall be redriven or jacked to the original elevation before testing. Unless otherwise specified in the contract, a minimum 3-day waiting period shall be observed between the driving of any anchor piles or the load test pile and the commencement of the load test.

Dynamic Pile Tests When a dynamic load test is specified in the contract documents, dynamic measurements will be taken by the Contractor using procedures set forth in ASTM D-4945 during the driving of piles designated by the Resident as dynamic load test piles. The dynamic tests are to be made by the Contractor's Engineer who shall be a licensed Professional Engineer. The same Contractor's Engineer conducting the wave equation analysis shall perform

the dynamic load tests. Each test shall also include a CAPWAP analysis in order to closely model actual field conditions the Contractor's Engineer shall be experienced in the used of the Pile Dynamic Analysis (PDA) equipment and its purpose related to pile capacity determinations. Dynamic measurements shall be reported to the Resident and include items specified in Section 7 of ASTM D4945.

Before placement of the pile in the leads, the Contractor shall make the designated pile available for obtaining wave speed measurements and for predrilling the required instrument attachment holes. Predriving wave speed measurements will not be required for steel piles. When wave speed measurements are made, the piling shall be in a horizontal position and not in contact with other piling. The Contractor will furnish the equipment, materials, and labor necessary for drilling holes in the piles for mounting the instruments. The instruments will be attached near the head of the pile with bolts placed through drilled holes on the steel piles or with wood screws for timber piles.

The Contractor shall provide the Contractor's dynamic testing engineer with reasonable means of access to the pile for attaching instrument after the pile is place in the leads. The Contractor shall furnish electric power for the dynamic test equipment. The power supply at the outlet shall be 10 amp, 115 volt, 55-60 cycle, A.C. only. Field generators used as the power source shall be equipped with functioning meters for monitoring voltage and frequency levels.

With the dynamic testing equipment attached, the Contractor shall drive the pile to the depth at which the dynamic test equipment indicates that the ultimate pile capacity, as called for on the plans, has been achieved, unless directed otherwise by the Resident. The stresses in the piles will be monitored during driving with the dynamic test equipment to ensure that the values determined do not exceed the allowable values in Section 501.04. If necessary, the Contractor shall reduce the driving energy transmitted to the pile by using additional cushions or reducing the energy output of the hammer in order to maintain stresses at or below the allowable values. If non-axial driving is indicated by dynamic test equipment measurements, the Contractor shall immediately realign the driving system.

When directed to retap by the Resident, the Contractor shall wait up to 24 hours and, after the instruments are reattached, retap (redrive) the dynamic load test pile. A cold hammer shall not be used for the redrive. The hammer shall be warmed up before redrive begins by applying at least 20 blows to another pile. The maximum amount of penetration required during redrive shall be 150 mm [6 in] or the maximum total number of hammer blows required will be 50, whichever occurs first. After retapping, the Resident will either provide the cutoff elevation or specify additional pile penetration and testing. The Contractor shall supply the Resident with a report of the test results of each dynamically tested pile and a CAPWAP analysis within ten days of the completion of testing.

Ultimate Pile Capacity Piles shall be driven by the Contractor to the penetration depth shown on the plans or to a greater depth if necessary to obtain the ultimate pile capacity. The ultimate pile capacity shall be determined by the Engineer based on one of the methods listed in Section 501.07. The ultimate capacity of piles driven with vibratory hammers shall be based on the criteria in Section 501.04

501.08 Test Piles (Indicator Piles) When required, test piles shall be driven as shown on the plans at the locations and to the lengths specified by the Resident. This work shall be accomplished before pile driving is allowed to commence. All test piles shall be driven with power hammers unless specifically stated otherwise in the plans. In general, the specified length of test piles will be greater than the estimated length of production piles in order to provide for variation in soil conditions. The driving equipment used for driving test piles shall be identical to that which the Contractor proposed to use on the production piling. Driving equipment shall conform to the requirements of Section 501.03. The Contractor shall bring the ground at each test pile to the elevation of the bottom of the footing before the pile is driven.

Test piles shall be driven to the driving resistance corresponding to ultimate capacity, as determined with the wave equation by the Resident, at the estimated tip elevation. Test piles that do not attain the hammer blow count specified above at a depth of 300 mm [1 ft] below the estimated tip elevation shown on the plans shall be allowed to "set up" for 24 hours, before being redriven. A cold hammer shall not be used for redrive. The hammer shall be warmed up before driving begins by applying at least 20 blows to another pile. If the specified hammer blow count is not attained on redriving, the Resident may direct the Contractor to drive a portion or all of the remaining test pile length and repeat the "set up" redrive procedure. If the specified hammer blow count is not attained on redriving and the full length of the pile had been driven, the Contractor shall splice and drive additional pile as directed by the Resident.

501.09 Splicing Piles Full-length piles shall always be used wherever practicable. When splices are unavoidable for piles, their number, locations and details shall be subject to approval of the Resident. If full-length piles cannot be used, piles shall not be spliced unless approved by the Resident. Piles fabricated from multiple pieces will be acceptable only if they comply with the following:

Piles lengths up to and including 6 m [20 ft] long - no splices allowed.
Piles lengths over 6 m up to and including 12 m [20 ft to 35 ft] - 1 splice, maximum, per pile.
Piles lengths over 12 m up to and including 24 m [35 ft to 79 ft] - 2 splices, maximum.
For pile lengths exceeding 24 m [79 ft], one splice per 12 meters [40 ft] will be permitted.

Sections less than 3 m [10 feet] in length will not be spliced except as a final (top) section of the pile.

When pre-planned splicing is permitted, the pile piece of lesser length shall be placed at the tip of the pile (the first part of the pile that enters the ground).

When splicing is authorized, piles shall be spliced as follows:

a. Damaged material shall be removed from the end of the driven pile. The ends of both sections to be spliced shall be cut off square with the longitudinal axis of the pile and scarifed as required. All cutting shall be done with the use of a mechanical guide and no free hand cutting will be allowed except for minor trimming.

b. A full penetration butt weld shall be used for the entire cross section of the pile.

c. All welding shall comply with the requirements of Section 504 - Structural Steel, except as modified hereinafter.

1. No run-off tabs will be required for flange butt welds on H-beam Piles.
2. No welding shall be done when the temperature in the immediate vicinity of the weld is below -20°C [0°F]; when the surfaces are damp or exposed to rain, snow, or high wind; or when the welders or welding operators are exposed to inclement conditions.
3. The pile shall be preheated to and maintained at 65°C [150°F] minimum within 150 mm [6 in] from the weld while welding.
4. The maximum electrode size shall be 4.76 mm [$^{3}/_{16}$ in].
5. Formal welding procedures need not be submitted.

d. Welders shall be prequalified in accordance with Section 504 - Structural Steel.

e. The Contractor may use mechanical splices, if approved by the Resident, and if the splice can transfer the full pile strength in bending, compression, and tension. Any alternate splices, so authorized, shall be capable of developing the full bending strength of the pile on both the x-x and y-y axis. If an H-pile splice incorporates a prefabricated pile splicer, the splicer shall be installed and welded as recommended by the manufacturer of the

splices and shall be supplemented with a partial penetration groove weld on each flange with a 45° bevel on the upper member of the splice and a groove depth of approximately 75% of the nominal flange thickness (AWS D1.1, BTC-P4-GF). All welding shall conform to the requirements of (c) above.

501.10 Prefabricated Pile Tips Steel H-beam piles shall be equipped with cast steel prefabricated pointed pile tips attached to the pile with a 8 mm [$^{5}/_{16}$ in] groove weld or equivalent along each flange. Welding shall be done using low-hydrogen electrodes and the base metal shall be preheated to 65°C [150°F] minimum.

Unless otherwise shown on the plans, steel pipe piles shall have pointed cast steel pile tips, welded as above specified for H-beam pile tips.

Pile tips for both H-beam and pipe piles shall be approved by the Resident.

Pile tips may be welded to the piles either by the supplier of the piles or in the field by the Contractor, at its option.

501.11 Method of Measurement

a. Equipment Mobilization A lump sum price bid for mobilization shall include the cost of furnishing all labor, materials, and equipment necessary for the transporting, erecting, dismantling, and removing the entire pile driving equipment.

b. Piles Furnished The unit of measurement for furnishing casings, timber, and steel shall be the meter [linear foot]. The quantity to be paid for will be the sum of the lengths in meters [feet] of the piles, of the types and lengths ordered in writing by the Resident. No allowance will be made for the length of piles, including test piles furnished by the Contractor, to replace piles that were previously accepted by the Resident, but are subsequently damaged prior to completion of the contract. When extensions of piles are necessary, the extension length ordered in writing by the Resident will be included in the length of piling furnished. All piles must be cutoff at the cutoff elevation shown on the plans. If the piles are cutoff at a higher elevation, the portion between these elevations will be deducted from this Item.

c. Piles in Place Initiation of pile installation by use of a vibratory hammer, preboring, jetting or other methods used for facilitating pile driving procedures will not be measured and payment shall be considered included in the unit price bid for the Piles Driven pay item.

The quantity of H-beam, cast-in-place pipe or shell concrete piles to be paid for will be the actual number of meters [linear feet] of steel pipe or shell piles driven, cast, and left in place in the completed and accepted work. Measurements will be made from the tip of the steel pipe, shell pile, or H-beam pile to the cutoff elevation as shown on the plans.

Unused pile cutoffs 6 m [20 ft] or more in length will remain the property of the Department and will be stored at a bridge maintenance yard nearest the project. Hauling and unloading of piles will be done by the Contractor or by the Department, depending upon availability of services.

When hauling and unloading is done by the Contractor, payment will be made under the provisions of Section 109 - Changes. There will be no separate payment to load piles at the project site; loading will be considered an incidental cost to the item.

The following are the locations and contact telephone numbers of all bridge maintenance yards throughout the State:

Division 1	New Limerick	Tel # 764-2060
Division 2	Hancock	Tel # 667-5556
Division 3	Carmel	Tel # 941-4553
Division 4	Skowhegan	Tel # 453-7377
Division 5	Washington	Tel # 596-2230
Division 6	Scarborough	Tel # 883-5546
Division 7	Farmington	Tel # 562-4228

The Resident will contact the Bridge Maintenance Managers at the above listed telephone numbers so that proper arrangements can be made for delivery.

No separate measurement will be made for reinforcing steel, excavation, drilling, cleaning of drilled holes, drilling fluids, sealing materials, concrete, required casing, and other items required to complete the work.

d. Pile Tips Pile Tips will be measured by the number of tips authorized and satisfactorily installed.

e. Pile Splices- Pile splices will be measured by the number of splices authorized and satisfactorily completed to drive the

piles in excess of the ordered length furnished and approved by the Resident.

f. Loading tests Load tests will be measured by the number of unit tests authorized and satisfactorily made.

g. Dynamic Load Test Dynamic load tests will be measured by the number of dynamic pile tests authorized and satisfactorily made. One dynamic test includes all data collected on one pile during both the initial pile driving and a retap done up to 24 hours after the initial driving

501.12 Basis of Payment. The accepted quantities of piles and casings will be paid for at the contract unit price per meter [linear foot], delivered, and complete in place. Such payment will include full compensation for any necessary excavation or backfilling required after driving, to bring the foundation area to the correct elevation.

Pile cutoffs and concrete for pipe piles and casings will not be paid for separately but will be considered as incidental to the related Pay Items. Damaged pile lengths removed for pile splicing will be considered incidental to the related Pay Items.

Excavating and cleaning steel pipe piles and steel casings, furnishing and placing reinforcing steel and steel templates in steel pipe piles and steel casings will not be paid for separately, but will be considered as incidental to the related Pay Items.

Preboring, jetting or other methods used to facilitate the driving of piling wall not be paid for separately, but will be considered incidental to the contract pay item for pile in place

Full compensation for all jetting, drilling, providing special driving tips or heavier sections for steel piles or shells, or other work necessary to obtain the specified penetration and bearing value of the piles, for drilling holes through embankment and filling the space remaining around the pile with sand or pea gravel, for disposing of material resulting from drilling holes, and for all excavation and backfill involved in constructing concrete extensions as shown on the plans, and as specified in these specifications and the special provisions, and as directed by the Engineer shall be considered as included in the contract unit price paid for drive pile or in the contract price paid per meter for cast-in-drilled-hole concrete piling, and no additional compensation will be allowed therefore.

Wave equation analyses and any subsequent wave equation analyses re-submittals, required to demonstrate the

appropriateness of the driving system, will be considered incidental to the related pay items.

Pile load tests, pile tips, and pile splices will be paid for at the contract unit price each.

Payment for dynamic pile tests will be at the contract unit price per pile tested. The price shall be full compensation for performing and collecting measurements from initial dynamic test, restrike tests, and CAPWAP analyses. The price shall include the cost for all sensors and wiring, monitoring equipment, setting up, monitoring personnel, and costs associated with the Contractors down time during regular working hours while setting up equipment and making dynamic measurements is being performed.

Payment will be made under:

Pay Items (as Furnished and in Place)		Pay Unit
501.230	Static Loading Test	Each
501.231	Dynamic Loading Test	Each
501.36	Steel H-beam Piles 53 kg/m (36 lb/ft), delivered	meter (Linear Foot)
501.361	Steel H-beam Piles 53 kg/m (36 lb/ft), in place	meter (Linear Foot)
501.38	Steel H-beam Piles 62 kg/m (42 lb/ft), delivered	meter (Linear Foot)
501.381	Steel H-beam Piles 62 kg/m (42 lb/ft), in place	meter (Linear Foot)
501.40	Steel H-beam Piles 79 kg/m (53 lb/ft), delivered	meter (Linear Foot)
501.401	Steel H-beam Piles 79 kg/m (53 lb/ft), in place	meter (Linear Foot)
501.42	Steel H-beam Piles 85 kg/m (57 lb/ft), delivered	meter (Linear Foot)
501.421	Steel H-beam Piles 85 kg/m (57 lb/ft), in place	meter (Linear Foot)
501.44	Steel H-beam Piles 93 kg/m (63 lb/ft), delivered	meter (Linear Foot)
501.441	Steel H-beam Piles 93 kg/m (63 lb/ft), in place	meter (Linear Foot)
501.46	Steel H-beam Piles 109 kg/m (73 lb/ft), delivered	meter (Linear Foot)
501.461	Steel H-beam Piles 109 kg/m (73 lb/ft), in place	meter (Linear Foot)
501.48	Steel H-beam Piles 110 kg/m (74 lb/ft), delivered	meter (Linear Foot)
501.481	Steel H-beam Piles 110 kg/m (74 lb/ft), in place	meter (Linear Foot)
501.50	Steel H-beam Piles 132 kg/m (89 lb/ft), delivered	meter (Linear Foot)
501.501	Steel H-beam Piles 132 kg/m (89 lb/ft), in place	meter (Linear Foot)

501.52	Steel H-beam Piles 152 kg/m (102 lb/ft), delivered	meter (Linear Foot)
501.521	Steel H-beam Piles 152 kg/m (102 lb/ft), in place	meter (Linear Foot)
501.54	Steel H-beam Piles 174 kg/m (117 lb/ft), delivered	meter (Linear Foot)
501.541	Steel H-beam Piles 174 kg/m (117 lb/ft), in place	meter (Linear Foot)
501.70	Steel Pipe Piles, delivered	meter (Linear Foot)
501.701	Steel Pipe Piles, in place	meter (Linear Foot)
501.72	Steel Casings, delivered	meter (Linear Foot)
501.721	Steel Casings, in place	meter (Linear Foot)
501.90	Pile Tips	Each
501.91	Pile Splices	Each
501.92	Pile Driving Equipment Mobilization	Lump Sum

SECTION 502 - STRUCTURAL CONCRETE

502.01 Description This work shall consist of furnishing and placing Portland Cement Concrete for structures and incidental construction in accordance with these Specifications and in conformity with the lines, grades, and dimensions shown on the Plans or established, or for placing concrete fill for foundations where called for on the Plans. For METHOD A Statistical Acceptance, or METHOD B Small Quantity Product Verification, the work shall conform to the Contractor's approved Quality Control (QC) Plan and Quality Assurance (QA) provisions, in accordance with these Specifications and the requirements of Section 106 - Quality. For METHOD C, the work shall conform to the requirements of this specification and Section 106- Quality.

502.02 Classification The Portland Cement Concrete shall be the class indicated on the Plans.

502.03 Materials Materials shall meet the requirements specified in the following Sections of Division 700 Materials:

Portland Cement and Portland Pozzolan Cement	701.01
Water	701.02
Air Entraining Admixtures	701.03
Water Reducing Admixtures	701.04
Water Reducing, High Range Admixture	701.0401
Set Retarding Admixtures	701.05
Curing Materials	701.06